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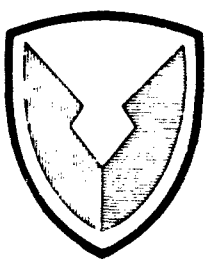
INFORMATION SOURCES ON RUBBER FOR ENGINEERS AND DESIGNERS



TECHNICAL REPORT

By

R. E. Ofner

September 1967

U. S. ARMY WEAPONS COMMAND

ROCK ISLAND ARSENAL

RESEARCH & ENGINEERING DIVISION

30

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TECHNICAL REPORT

67-2384

INFORMATION SOURCES ON RUBBER FOR ENGINEERS AND DESIGNERS

By

Robert E. Ofner
Research Laboratories

September 1967

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ABSTRACT

Sources of information, such as design handbooks, specifications and technical journals and books on engineering, are provided for use by design engineers in the application of rubber to Army weapon systems.

TABLE OF CONTENTS

OBJECTIVE

To provide information sources on rubber, such as design handbooks, technical books, journals and specifications, which should be useful to design engineers in the application of rubber to Army weapon systems.

BACKGROUND

The design of rubber components for use in Army weapon systems frequently raises questions in the mind of the engineer. The following examples are cited to demonstrate the diversity of functions and requirements of the rubber items normally employed in weapons and the broad scope of information which should be available to the engineer to aid him in the design of such items.

For example, the O-ring seal for use in the hydraulic mechanism prompts questions relative to [illegible]ction between rubber and metal and compatibility between rubber and hydraulic fluid. The sponge rubber headrest used in conjunction with fire control equipment brings to mind the problems of retention of satisfactory cushioning effects over a broad temperature range and the bleeding of rubber constituents from headrest to the human skin. The gun breech obturator prompts inquires relative to gas sealing capabilities over wide pressure and temperature ranges. The boot of the traversing mechanism draws attention to the need for low temperature flexibility and resistance to puncture. The protective gun or vehicle cover poses problems pertaining to abrasion and weather resistance and waterproofness.

It is well recognized that complete design and engineering guidelines for rubber components of weapons cannot be found in one document. However, there do exist many time proven sources of information on designing with rubber. It is the purpose of this report to guide the engineer to these source materials.

Engineering Books

Stress-Strain Behavior of Elastic Materials, O. H. Varga, 1966, Wiley

Rubber In Engineering Practice, A. B. Davey and A. R. Payne, 1964, Palmerton

The Chemistry and Physics of Rubber-Like Substances, L. Bateman, 1963, Wiley

Engineering Design with Rubber, A. R. Payne and J. R. Scott, 1960, Interscience

The Physics of Rubber Elasticity, L. R. G. Treloar, 1958, Oxford University Press

Engineering Uses of Rubber, A. T. McPherson and A. Klemin, 1956, Reinhold

Rubber in Automobile Engineering, R. Dean-Averns, 1956, Brown Knight and Truscott, London

Engineering Properties of Rubber, 1950, United States Rubber Co.

Engineering with Rubber, W. E. Burton, 1949, McGraw-Hill

Technology Books

Testing of Polymers, J. V. Schmitz, Vol 1 (1965), Vol 2 (1966), Wiley

Polymer Technology, D. C. Miles and J. H. Briston, 1965, Chemical Publishing Co.

Materials and Compounding Ingredients for Rubber and Plastics, 1965, Rubber World

Physical Testing of Rubber, J. R. Scott, 1965, Palmerton

Vulcanization of Elastomers, G. Alliger and I. J. Sjothun, 1964, Reinhold

Rubber Technology - A Basic Course, A. S. Craig, 1963, Oliver and Boyd, London

Machinery and Equipment for Rubber and Plastics, 1963 Rubber World

The Language of Rubber, 1963, duPont

The Neoprenes, R. M. Murray and D. C. Thompson, 1963, duPont

Synthetic Rubber Technology - Compounding, Processing and Application, W. S. Penn, 1960, Maclaren

Rubber to Metal Bonding, S. Buchan, 1959, Palmerton

Conductive Rubber, R. H. Norman, 1957, Maclaren

Rubber-Fundamentals of Its Science and Technology, J. LeBras, 1957, Chemical Publishing Co.

Glossary of Terms Relating to Rubber and Rubber-Like Materials, 1956, ASTM STP184

Mechanical Molded Goods, D. C. Thompson, 1955, duPont

Synthetic Rubber, G. S. Whitby, 1954, Wiley

Glossary of Terms Used by the Mechanical Rubber Goods Industry, 1954, Rubber Manufacturers Association

Design Handbooks for Rubber and Related Materials

Military Handbooks

MIL-HDBK-149, Rubber and Rubber-Like Materials

MIL-HDBK-212, Gasket Materials (Nonmetallic)

MIL-HDBK-691, Adhesives

MIL-HDBK-692, A Guide to the Selection of Rubber O-Rings

WADC Technical Report 59-428, Design Handbook for O-Rings and Similar Elastic Seals, AD #230639

Aeronautical Systems Division Technical Report 61-234, Handbook of Design Data on Elastomeric Materials Used in Aerospace Systems, PDL-43586

Aeronautical Systems Division Technical Report 61-297, A User-Oriented Data Guide to Potting and Encapsulating Compounds

Industrial Handbooks

A. General

1967 SAE Handbook, Society of Automotive Engineers

Rubber Handbook, Specifications for Rubber Products, 2nd Edition, 1963, Rubber Manufacturers Association

Handbook of Molded and Extruded Rubber, 2nd Edition, 1962, The Goodyear Tire and Rubber Co.

Mechanical Characteristics and Applications of Rubber, 2nd Edition, 1961, B. F. Goodrich Industrial Products Co.

The Vanderbilt Rubber Handbook, 10th Edition, 1958, R. T. Vanderbilt Co.

N.R.P.R.A. Technical Bulletin No. 8, Engineering Design With Natural Rubber, Natural Rubber Producers' Research Association

Special Report on Engineering Elastomers, Product Engineering Magazine, 8 Jan. 1962, McGraw-Hill Publishing Co.

B. Seals (Gaskets and Packings)

Seals, 11 June 1964 issue of Machine Design, Penton Publishing Co.

Manufacturer's Handbooks - Nearly all major manufacturers of gaskets and packings publish handbocks on O-rings, hydraulic packings, seals, etc.

C. Specific Rubber Items

Hose Handbook, 2nd Edition, 1965, Rubber Manufacturers Association

Handbook for Specifications and Tolerances for Rubber-Covered Rolls, 1962, Rubber Manufacturers Association

Rubber Sheet Packing Handbook, 1962, Rubber Manufacturers Association

Technical and Trade Journals

This list of journals is limited to those which feature articles on design, engineering and physical properties and applications. Journals dealing primarily with the chemistry, physics and synthesis of rubber are excluded.

Title	Publisher
Adhesives Age - monthly	Palmerton Publishing Co.
Industrial & Engineering Chemistry, Product Research and Development - monthly	American Chemical Society
Industrial & Engineering Chemistry, Process Design and Development - monthly	American Chemical Society
Insulation - monthly	Lake Publishing Corp.
Machine Design - monthly	Penton Publishing Co.
Materials in Design Engineering - monthly	Reinhold Publishing Corp.
Materials Research and Standards - monthly	American Society for Testing and Materials
Rubber Age - monthly	Palmerton Publishing Co.
Rubber Chemistry and Technology - quarterly	Division of Rubber Chemistry of the American Chemical Society
Rubber World - monthly	Bill Brothers Publishing Co.
The SAE Journal - monthly	Society of Automotive Engineers

Abstracts, Bibliographies and Reviews

Abstracts

There is no well established abstracting service devoted entirely to the world's published literature on rubber. The first of the four services listed below includes rubber in its coverage of the world's chemical literature. The second and third services abstract reports generated by the U. S. Government and its contractors. The fourth service is devoted entirely to literature on urethane rubbers.

Title	Publisher
Chemical Abstracts, Macromolecular Sections, biweekly	American Chemical Society
Technical Abstract Bulletin, semi-monthly	Defense Documentation Center
Scientific and Technical Aerospace Reports, semi-monthly	National Aeronautics and Space Administration
Urethane Industry Digest, semi-monthly	Urethane Industry Digest, Chicago, Illinois

Bibliographies

The Rubber Division Library, University of Akron, Akron, Ohio 44304, publishes bibliographies on specific areas of rubber technology.

The Division of Rubber Chemistry, American Chemical Society, has published fourteen volumes of "Bibliography of Rubber Literature," covering the period from 1936 to 1960. More recent volumes are under preparation.

Defense Documentation Center will prepare bibliographies covering DDC reports upon receipt of DDC Form 4.

Reviews

The National Bureau of Standards prepares an annual review article on test methods pertaining to natural and synthetic rubbers which appears in the Analytical Chemistry journal.

The Industrial Engineering Chemistry journal publishes an annual review article on the year's most important technological developments on rubber.

Trade Bulletins

These house organs of rubber and rubber end item manufacturers deal primarily with new applications for rubber and improved methods for compounding rubber to achieve desired properties. Subscriptions to these bulletins are free.

Title	Subject	Source
Aerospace Facts	Rocket and Space Applications	Thiokol Chemical Corp.
Dynafacts	Vibration/shock/ noise Control	Lord Manufacturing Co.
The Elastomer Notebook	Applications - Hypalon, Neoprene and Viton Rubbers	duPont
Enjay Rubber Reporter	Applications - Butyl and EP Rubbers	Enjay Chemical Co.
Estane Newsletters	Applications - urethane Rubber	B. F. Goodrich Co.
Findings	Applications and Compounding for EP and Nitrile Rubbers	Uniroyal Chemical
Materials News	Silicone Rubber Applications	Dow Corning Corp.
Natural Rubber Technical Bulletin	Compounding Natural Rubber	National Rubber Bureau
Rubber Developments	Natural Rubber Applications	Natural Rubber Producers' Research Association
Silicology	Silicone Rubber Applications	Union Carbide Corp.
Texin Topics	Urethane Rubber Applications	Mobay Chemical Co.
The Vanderbilt News	Compounding	R. T. Vanderbilt Co.

Trade Names

Title	Publisher
U.S.A.	
The American Trademark Index - Leading Trademarks and Brand Names, Vol. IV of Thomas Register of American Manufacturers - published annually	Thomas Publishing Co., N.Y., N.Y.
Handbook of Material Trade Names, O. T. Zimmerman and I. Lavine, 1953 Supplements I (1956), II (1957), III (1960), IV (1965)	Industrial Research Service, Dover, N.H.
Trade Name Section, Vol 1 of MacRae's Corporate Index Blue Book - published annually	MacRae's, Western Springs, Ill.
Great Britain	
Annotated Comprehensive List of Trade Names of Synthetics Vol. 1, 1926-1949 Vol. 2, 1949-1954	RABRM[1]
Trade Names Vol. 1, 1926-1949 Vol. 2, 1950-1955	RPRA[2]
Trade Names of Rubbers, Resins and Plastics Vol. 3, 1955-1959	RPRA
Trade Names of Rubbers, Resins and Plastics, 1960	RPRA
Trade Names of Rubbers, Resins and Plastics, 1961	RPRA
New Trade Names in the Rubber and Plastics Industries, 1962	RPRA
New Trade Names in the Rubber and Plastics Industries, 1963	RPRA

[1]Research Association of British Rubber Manufacturers.

[2]Rubber and Plastics Research Association of Great Britain.

Technical Societies

Title	Address
American Chemical Society, Division of Rubber Chemistry	University of Akron, Akron, Ohio 44304
American Society of Mechanical Engineers, Rubber and Plastics Division	345 East 47th Street New York, N.Y.
American Society for Testing and Materials	1916 Race Street Philadelphia, Pa. 19103
Natural Rubber Bureau	1108 Sixteenth St. N. W., Washington, D. C. 20036
Rubber Export Association	Seven West Bowery Street Akron, Ohio
The Rubber Manufacturers Association	444 Madison Avenue New York, N.Y. 10022
Society of Automotive Engineers	485 Lexington Avenue New York, N.Y. 10017
Tire and Rim Association	34 North Hawkins Avenue Akron, Ohio
United States of America Standards Institute	10 East 40th Street New York, N.Y. 10016

Military Laboratories
Engaging in Rubber Research and Development

Army

Materials Laboratory, U. S. Army Tank-Automotive Center, Warren, Michigan 48090

Non metallic Materials Laboratory, U. S. Army Weapons Command, Rock Island Arsenal, Rock Island, Illinois 61202

U. S. Army Engineer Research and Development Labs., Fort Belvoir, Virginia 22060

U. S. Army Natick Laboratories, Natick, Massachusetts 01760

Navy

Naval Research Laboratory, Washington, D. C. 20390

San Francisco Bay Naval Shipyard, Mare Island Division, Vallejo, California 94592

U. S. Naval Applied Science Laboratory, U. S. Naval Base, Brooklyn, New York 11251

Air Force

Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio 45433

Personnel Directories

Title	Publisher
Directory in Plastics - Knowledgeable Government Personnel, PLASTEC Report 5B, 1966	Plastics Technical Evaluation Center (PLASTEC), Picatinny Arsenal, Dover, N.J.
Directory of ASTM Committee D-11 on Rubber and Rubber Like Materials - every two years	American Society for Testing and Materials
Directory of the Division of Rubber Chemistry, American Chemical Society - annual	American Chemical Society
Rubber Red Book - annual	Palmerton Publishing Co., Inc., N. Y., N. Y.

Test Standards and Methods

There are three major standards of test methods for rubber, as listed below. ASTM test methods are the most widely accepted in the U. S. A. The following list of test methods is by no means complete, there being about 170 ASTM methods for rubber. The list is for those methods most frequently used.

Standards

Title	Publisher
1967 Book of ASTM Standards, Part 28, Rubber; Carbon Black; Gaskets	ASTM
Federal Test Method Standard No. 601, Rubber: Sampling and Testing	General Services Administration, Washington, D. C.
British Standard 903, Methods of Testing Vulcanized Rubber	British Standards Institution, London, England

Test Methods - Physical Tests	ASTM Method
Abrasion resistance	D394 and D2228
Adhesion, rubber to metal	D429
Compression - deflection	D575
Compression set	D395, Method B
Hardness, Shore Durometer A	D2240
Immersion in liquids	D471
Resilience	D945
Tear resistance	[illegible]
Tension, elongation, modulus	[illegible]
Tension testing O-rings	D1414
Vibration (forced)	D2231

Test Methods - Aging and Weathering	ASTM Method
Air oven	D573
Ozone resistance	D1149

Test Methods - Low Temperature	ASTM Method
Brittleness	D746
Compression set	D1229
Stiffness, torsion	D1043 and D1053
Temperature-retraction	D1329
General procedures for conditioning	D832

Test Methods - General	ASTM Method
Interlaboratory tests	D1421
Standard test temperatures	D1349

Military and Industry Specifications and Standards

Classification Systems (Descriptions of callouts for rubber grades on drawings and other procurement documents):

ASTM D2000, Classification System for Elastomeric Materials for Automotive Applications

MIL-STD-417, Rubber Composition, Vulcanized General Purpose, Solid

MIL-STD-670, Classification System and Tests for Cellular Elastomeric Materials

Procurement Specifications

A. Multipurpose (For the procurement of a variety of products, such as molded goods, extruded shapes, calendered goods, sheet packing and cellular products).

ZZ-R-765 Rubber, Silicone, Low and High Temperature and Tear Resistant

MIL-R-3065 Rubber, Fabricated Parts

MIL-C-3133 Cellular Elastomeric Materials, Fabricated Parts

MIL-S-6855 Synthetic Rubber Sheets, Strips, Molded or Extruded Shapes

MIL-R-7362 Rubber, Synthetic, Solid, Sheet and Fabricated Parts, Synthetic Oil Resistant

MIL-R-25897 Rubber, High Temperature, Fluid Resistant

B. Specific Items - MIL-HDBK-699, A Guide to the Specifications for Flexible Rubber Products, lists all known Military, federal and technical society specifications for the following types of rubber products. Major requirements of each specification are also listed.

Clothing, Coated fabrics, Hose, Mats, O-rings, Packings and gaskets, Tires and Wire and Cable.

Documents Pertaining to O-Rings

AIR63 - Aerospace Information Report, O-Ring Size and Part Number Cross-Reference Chart*

ARP568 - Aerospace Recommended Practice, Uniform Dash Numbering System for O-Rings*

AIR786 - Aerospace Information Report, Elastomer Compatibility Considerations Relative to O-Ring and Sealant Selection*

MIL-STD-413 - Visual Inspection Guide for Rubber O-Rings

MIL-HDBK-692 - A Guide to the Selection of Rubber O-Rings

*Available from Society of Automotive Engineers

Information on Shelf Storage Life

Dept. of the Army Supply Bulletin, SB740-60, Storage, Inspection and Shelf-Life Information for Deteriorating Items

MIL-HDBK-695, Rubber Products: Shelf Storage Life

DSA DISC Regulation Nr. 4151.1, Deteriorative Material

George C. Marshall Space Flight Center Report MIP-P&VE-M-62-6, March 1962, Aging of Installed Rubber and Plastic Gaskets in Simulated Flight Hardware

U. S. Naval Applied Science Laboratory Report No. 30-909-1, Sept. 1965, Standardization Program on Shelf Aging of Natural and Synthetic Rubber Materials

Mare Island Naval Shipyard Report No. 92-7, Effect of Shelf Aging on MIL-P-5516 O-Rings

Visual Inspection Guides

These inspection guides provide criteria for establishing the acceptable quality of rubber products for Military use.

MIL-STD-166	Visual Inspection Guide for Rubber Hose
MIL-STD-168	Visual Inspection Guide for All-Rubber Gloves (Except Surgical)
MIL-STD-177	Rubber Products, Terms for Visible Defects of
MIL-STD-284	Visual Inspection Guide for Rubber Footwear
MIL-STD-289	Visual Inspection Guide for Rubber Sheet Material
MIL-STD-293	Visual Inspection Guide for Cellular Rubber Items
MIL-STD-294	Visual Inspection Guide for Rubber V-Belts
MIL-STD-297	Visual Inspection Guide for Hard Rubber (Ebonite) Items
MIL-STD-298	Visual Inspection Guide for Rubber Extruded Goods
MIL-STD-407	Visual Inspection Guide for Rubber Molded Items
MIL-STD-413	Visual Inspection Guide for Rubber O-Rings

Documents Pertaining to Color Coding and Marking

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-190	Identification Marking of Rubber Products
MIL-STD-686	Cable and Cord, Electrical, Identification Marking and Color Coding of

Stock Lists, Price Lists and Vendor's Guides

Stock Lists

Descriptions of many of the rubber items used and stocked by the Department of Defense may be found in the following Federal Supply Catalog Identification Lists:

C9300-IL-A
C9300-IL-AF
C9300-IL-MC
C9300-IL-N

Descriptions of rubber O-rings, packings and gaskets used and stocked by the DOD may be found in the C5330-IL series of the Federal Supply Catalog Identification Lists.

Price Lists

Prices of the rubber items listed in the C9300 and C5330 Identification Lists may be found in the C9300-ML and C5330-ML series, known as the Federal Supply Catalog Management Data Lists.

Vendor's Guides

Lists of manufacturers of items procured by agencies of the Federal Government are available. Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) list manufacturers, their addresses and Federal Code Number, for all types of procured items, including rubber items.

The Rubber Manufacturers Association publishes a "Vendor's Identification Guide" for molded and extruded rubber and plastic products which lists manufacturer's names and their code letter identification which usually appears on their products.

Designations for Commercially Available Types of Rubber

Common Designation	Chemical Description	ASTM D1418 Abbreviation	ASTM D2000 Designation	MIL-STD-417 Designation
Natural	cis-1,4-polyisoprene	NR	AA	RN
Synthetic natural	cis-1,4-polyisoprene	IR	AA	RN
Butadiene	cis-1,4-polybutadiene	BR	AA	RS
SBR	Copolymer of butadiene/ styrene	SBR	AA, BA	RS
Butyl	Copolymer of isobutylene/isoprene	IIR	AA, BA	RS
Chloro or bromo butyl	Halogenated copolymer of isobutylene/isoprene	-	-	-
EPR	Copolymer of ethylene/ propylene	EPM	CA	-
EPT	Terpolymer of ethylene/ propylene and a diene	EPDM	CA	-
Neoprene	Polychloroprene	CR	BC, BE	SC
Nitrile	Copolymer of butadiene/ acrylonitrile	NBR	BF, BG, CH	SB
Urethane	Polyester urethane	AU	BG	-
Urethane	Polyether urethane	EU	BG	-
Thiokol	Polysulfide	-	BK	SA
Hypalon	Chlorosulfonated polyethylene	CSM	CE	-
Acrylic	Copolymer of an acrylate and 2-chloroethyl vinyl ether	ACM	DF, DH	TB
Acrylic	Copolymer of an acrylate and acrylonitrile	ANM	DF, DH	TB

Common Designation	Chemical Description	ASTM D1418 Abbreviation	ASTM D2000 Designation	MIL-STD-417 Designation
Silicone	Polysiloxane	Si, PSi, VSi, PVSi	FC, FE, GE	TA
Fluorosilicone	Fluorinated polysiloxane	FSi	FK	TA
Fluoroelastomer	Copolymer of vinylidine fluoride and hexafluoropropylene	FPM	HK	-
Chlorinated polyethylene	Chloropolyethylene	CM	-	-
ECH	Polychloromethyl oxirane (epichlorohydrin)	CO	-	-
ECH copolymer	Copolymer of ethylene oxide and chloromethyl oxirane	ECO	-	-

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13. ABSTRACT
Sources of information, such as design handbooks, specifications and technical journals and books on engineering, are provided for use by design engineers in the application of rubber to Army weapon systems. (U) (Author)

DD FORM 1 NOV 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Elastomers						
Rubber						
Design						
Engineering						
Handbooks						
Specifications						

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